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INTAKE AIR HEATER AND AIR DELIVERY
ASSEMBLY FOR ENGINES

Technical Field

5 This invention relates to an improved intake air heater assembly for
an internal combustion engine which permits simple, effective mounting of
the air heater on the engine while minimizing the size of the engine.

Background of the Invention

10 It is well known that when ambient air temperatures are sufficiently
low, a diesel engine requires assistance, such as the heating of intake air,
to enable the engine to start. As a result, efforts have been made to
improve cold engine starting and warming-up providing a means for
increasing the temperature of the intake air. In addition, modern
turbocharged and aftercooled engines require heating of intake air during
certain operating conditions to avoid the occurrence of white smoke and
15 other undesirable exhaust emissions. U.S. Patent No. 3,977,377 to Reid
discloses one approach to heating the intake air which includes a burner for
injecting a spray of fuel into a burner assembly for combustion with intake
air. A flame is produced which heats the intake air sufficiently to permit
start up or minimize white smoke emissions. However, the burner
20 assembly requires a separate housing mounted on an intake manifold which
is formed separately from the engine cylinder head. Therefore, the burner
assembly of Reid disadvantageously increases the overall size of the
engine. Moreover, burner type air heaters have been found inferior to
other heaters in certain applications, and are often complex and expensive
25 as compared to other viable heating systems.

Another type of conventional air heater is an electrical resistance heater using a pattern of wires which generate heat when carrying electric current. U.S. Patent No. 1,276,083 to Lake discloses one type of electrical heater for an engine including a ring positioned in each cylinder
5 of the engine. The ring is connected to a source of electric power and becomes sufficiently hot when subjected to current so as to raise the temperature within the combustion chamber prior to starting the engine thereby ensuring fuel ignition and engine starting. However, this design requires an electric plate in each engine cylinder and therefore is expensive
10 and difficult to maintain. Moreover, this design requires a specifically designed cylinder head with various connections not found on many conventional engines. Therefore, the Lake heater could not be retrofitted on most existing engines without unreasonable costs associated with either major modifications to existing cylinder heads or providing a completely
15 new cylinder head. U.S. Patent Nos. 909,898, 909,899 and 1,327,384 all disclose electrical fuel vaporizers positioned in the engine cylinders for assisting in the ignition of fuel. However, these devices all suffer from the same drawbacks of the heater disclosed in Lake.

U.S. Patent Nos. 4,682,576 to Nakamura et al. and 2,177,840 to
20 Roulalet both disclose an electric air heater positioned in an intake air manifold. However, the electric heater is positioned upstream of the cylinder head and the intake manifold is formed separately from the engine cylinder head. Consequently, the mounting of the heater increases the number of joints along the manifold which must be sealed. In addition, the
25 air heater and manifold add to the outer extent of the engine thus often increasing the size of the engine beyond the packaging constraints of a particular application.

German Publication No. 4121075 generally discloses an air heater positioned in a branch duct communicating with only one cylinder. U.S. Patent Nos. 2,139,777, 4,108,953 and 4,325,344 all disclose fuel vaporizing devices mounted in intake manifolds formed separately from an engine cylinder head. The heaters and air delivery assemblies disclosed in all these references suffer from many of the disadvantages noted hereinabove.

Consequently, there is a need for an intake air heater and air delivery assembly capable of simple, inexpensive integrated mounting on engines while minimizing the size of the engine.

Summary of the Invention

It is an object of the present invention, therefore, to overcome the disadvantages of the prior art and to provide a simple, inexpensive air heater and air delivery system capable of effectively heating the engine intake air.

It is another object of the present invention to provide an air heater capable of being mounted in an intake manifold formed integrally in a cylinder head of an engine.

It is yet another object of the present invention to provide an air heater for mounting in an air delivery system so as to minimize the size of the intake assembly thereby minimizing the size of the engine.

It is a further object of the present invention to provide an air heater positioned in an elongated air manifold which is capable of effectively heating the intake air flowing through the elongated manifold so as to aid in cold engine starting.

Another object of the present invention is to provide an air heater capable of being easily mounted on existing engines without significantly affecting the size of an intake air delivery assembly thereby maintaining the size of the engine within the packaging constraints of the engine application.

Yet another object of the present invention is to provide a unitized air delivery assembly including an intake manifold and heater integrated into the engine cylinder head.

These and other objects are achieved by providing an intake air heater capable of being mounted in an intake air manifold formed integrally in a cylinder head of an internal combustion engine for heating intake air flowing along an intake air flow path to multiple engine cylinders, comprising a heater frame member for attachment to the cylinder head and a heating element connected to the heater frame member for heating the intake air. The heating element is positioned within the integral intake air manifold formed in the cylinder head when the heater is mounted on the engine. The frame member further includes a flange portion positioned substantially in a single mounting plane so that the heating element is positioned on one side of the mounting plane along the intake air flow path downstream of the flange portion. The frame member may be elongated in shape and the flange portion may extend peripherally around the elongated frame member. Also, the frame member may include two side wall portions extending from the flange portion transverse to the mounting plane. The heating element is mounted between the two side wall portions and may include an electric resistance heater. One of the side wall portions may include an access port for providing access for an electrical connection between an electrical source and the heating element.

5 The present invention also provides an intake air delivery assembly for delivering intake air to multiple cylinders of an internal combustion engine having an engine block, comprising a cylinder head mounted on the engine block and including an integral intake manifold chamber formed therein for delivering intake air to the multiple cylinders of the engine. The intake air heater is mounted at least partially in the integral intake manifold chamber which may be formed in the top surface of the cylinder head opposite a cylinder head bottom surface engaging the cylinder block. The cylinder head preferably includes a connector aperture formed in one of its side surfaces for receiving an electrical connector connecting the heating element to an electrical source. The heater frame includes a mounting flange extending along the top surface of the cylinder block and side walls extending from the mounting flange into the integral intake manifold chamber for supporting the heating element. The air delivery assembly may further include an air delivery conduit mounted adjacent the top surface of the cylinder head. The delivery conduit defines an air delivery passage communicating with the integral intake manifold and includes a conduit flange. The conduit flange, heater mounting flange and the top surface of this cylinder head each include a plurality of mounting apertures, sets of which are aligned to receive respective mounting bolts for securing the flanges together.

25 The present invention also provides an intake air delivery assembly including a cylinder head having an integral intake manifold chamber for delivering intake air to multiple cylinders of the engine. The cylinder head includes a first surface for engaging the cylinder block and a second surface formed opposite the first surface. The intake air delivery assembly further includes an air delivery conduit mounted on the cylinder head

adjacent to second surface for defining an air delivery passage. The assembly also includes an intake air heater including a heating element positioned in one or both of the integral intake manifold and the delivery conduit. The heater also includes a heater frame member for supporting
5 the heating element which includes a flange portion positioned in compressive abutting relationship between the air delivery conduit and the second surface of the cylinder head. The flange portion of the frame member has a predetermined minimal thickness for minimizing the distance between the air delivery conduit and the top surface of the cylinder head.

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Brief Description of the Drawings

FIG. 1 is an end view of an engine incorporating the air heater and air delivery assembly of the present invention;

FIG. 2 is an elevational assembly drawing illustrating the connection of the components of the air delivery assembly of the present invention;

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FIG. 3 is a perspective view of the air heater of the present invention; and

FIG. 4 is a partial cross sectional view of the air delivery assembly of the present invention.

Detailed Description of the Preferred Embodiment

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Referring to FIGS. 1 and 2, there is shown the air heater 10 of the present invention and the air delivery assembly 12 of the present invention as applied to a 6-cylinder engine having an engine block 14 containing engine cylinders (not shown). Generally, the air delivery assembly 12 includes the intake air heater 10 connected between a cylinder head 16 of

the engine and an air delivery conduit 18 so that heater 10 can be selectively energized to heat the intake air flowing into the engine.

5 The cylinder head 16 includes a bottom surface 20 mounted in abutment with engine block 14, a top surface 22 formed opposite bottom surface 20 and side surfaces 24 connecting bottom surface 20 and top surface 22. A generally elongated intake air manifold 26 is formed integrally in cylinder head 16 and extending inwardly from top surface 22. Integral intake air manifold 26 is designed to deliver intake air received from air delivery conduit 18 to the various intake passages leading to each
10 engine cylinder.

Air delivery conduit 18 includes an inlet port 28 for receiving intake air from, for example, a turbocharger 30 and an elongated outlet 29 for directing air into manifold 26. Conduit 18 also includes a conduit flange 32 extending around the periphery of outlet 29 to form a generally
15 rectangularly shaped mounting surface corresponding to the top surface 22 of cylinder head 16 located around the periphery of intake air manifold 26. Air delivery conduit 18 also includes mounting apertures 34 formed in conduit flange 32 for alignment with corresponding apertures 36 formed in the top surface 22 of cylinder head 16. Air delivery conduit 18 may
20 function not only as an intake manifold cover for directing intake air into integral intake manifold 26, but also as an aftercooler or heat exchanger. As an aftercooler, conduit 18 functions to cool the intake air to increase the charge density of the air thereby permitting increased volumetric efficiency for improved engine performance. Conduit or aftercooler 18 includes an
25 engine coolant inlet and outlet connections 38, 40 providing engine coolant flow through a bundle of tubes or heat exchanger passages (not shown) positioned within conduit 18.

In order to ensure optimum operation of the intake air heater assembly of the present invention, intake air heater 10 is positioned between conduit or aftercooler 18 and the intake ports of each engine cylinder. Intake air heater 10 includes a heater frame member 42 and a heating element 44 supported by frame 42. As shown in FIGS. 2 and 3, heater frame 42 includes a mounting flange portion 46 corresponding generally to the shape of conduit flange 32. Flange portion 46 includes mounting apertures 48 corresponding to and positioned for alignment with mounting apertures 34 and 36 of conduit flange 32 and cylinder head 16, respectively. A gasket 49 provides a sealed connection between flange 46 and cylinder head 16. Bolts 51 extend through each aligned set of mounting apertures to secure conduit 18 and heater 10 to cylinder head 16. Flange portion 46 is positioned generally in a single mounting plane for positioning between conduit flange 32 and top surface 22. Frame 42 further includes opposed side walls 50, each extending transversely in one direction from the inner edge of frame member 42. Each side wall 50 includes two spaced apart rails 52 extending toward the opposed side wall to form opposed elongated mounting grooves 54.

Heating element 44 is positioned between side walls 50 in each mounting groove 54. Heating element 44 is preferably an electric resistance heater formed from an elongated strip of electrical resistance material bent to form multiple spaced heating panels 56 extending between side walls 50. As shown in FIG. 3, heating element 44 is electrically isolated from frame 42 except at a ground connection at one end to heater frame 42 via a screw 58. An opposite end 60 of heating element 44 is connected to an electrical source via an electrical connector 62. Heater

frame 42 is grounded by a grounding strap 61 connected at one end to a tab 63 extending from flange 46 and at an opposite end to the engine.

Referring to FIG. 4, heater frame 42 further includes upper and lower transverse walls 64 and 66, respectively, extending between side walls 50 at the opposite end 60 of heating element 44. A vertical wall 68, positioned intermediate side walls 50, connects upper and lower walls 64, 66. Vertical wall 68 includes a central passage 70 within which an insulating grommet 72 is positioned. Side walls 50 of frame 42 each include an access port 74 positioned in alignment with central passage 70. Electrical connector 62 includes a cap screw 76 and an elongated nut 78 having a central bore 80. Cap screw 76 extends through an aperture formed in opposite end 60 of heating element 44 and through central passage 70 into central bore 80 so as to threadably engage nut 78. A set of washers positioned on both sides of vertical wall 68 separate nut 78 and the opposite end 60 of heating element 44 from contacting vertical wall 68 of frame 42. Moreover, cap screw 76 and nut 78 are formed of an electrically conductive material while grommet 72 and at least one of the washers on both sides of wall 68 are formed of an insulating material so as to electrically isolate nut 78, cap screw 76 and opposite end 60 from frame member 42.

A connector aperture 82 is formed in the side wall of cylinder head 16 in alignment with one of the access ports 74. The electrical connector 62 further includes an adapter plug 84 threadably secured to cylinder block 16 in connector aperture 82. Adapter plug 84 includes a center passage 86 for receiving a hollow insulating sleeve 88. A threaded rod 90 extends through center passage 86 and hollow insulating sleeve 88 into central bore 80 of nut 78 engaging complimentary threads formed on the inner surface

of nut 78. A lock nut 92 threaded on, or formed integrally with, rod 90 abuts insulating sleeve 88 to secure sleeve 88 and rod 90 in place. As a result, an insulated electrical connection is created between opposite end 60 of heating element 44 and the outer end of rod 90 which may then be
5 connected to an electrical source for providing current to heating element 44.

In operation, the air heater of the present invention can be selectively energized through a conventional and well known control system to heat the intake air flowing from the conduit or aftercooler 18 to improve
10 cold engine starting and enhance engine warm-up. Intake air heater 10 may also be used during certain periods of engine operation to improve the combustion process. Heating element 44 is elongated in shape so as to extend through a significant portion of integral intake air manifold 26 thereby providing exceptional heat distribution.

15 The intake air heater 10 and air delivery assembly 12 of the present invention provide distinct advantages over conventional air heater and delivery assemblies. Many conventional air delivery assemblies provide an air heater housing mounted along the air delivery conduit so that the height or width of the air heater housing contributes significantly to the
20 total height or width of the engine. However, the increase in engine size often renders the engine size outside the packaging limits of a particular engine application. Moreover, conventional intake air housings cannot be easily retrofitted on existing engines. The present invention results in many advantages over conventional air delivery assemblies by providing an
25 intake air heater capable of being suspended in an integral intake air manifold formed in the cylinder head of the engine. By combining the use of an integral intake manifold 26 with the uniquely designed intake air

heater 10 of the present invention, an air delivery assembly is produced which advantageously utilizes the volume of the integral intake air manifold for housing intake air heater 10. As a result, substantially the entire heater including frame member 42 and heating element 44 are positioned within integral intake air manifold 26. By overlapping the air ^{heater}~~filter~~ and the cylinder head and limiting the portion of frame member 42 extending outside integral intake air manifold 26, the integrated air delivery and heater assembly of the present invention minimizes the size of the engine thereby permitting use of the engine in a greater number of applications having engine packaging size limitations.

In addition, by using a simple flange arrangement, the air heater 10 of the present invention can be easily retrofitted on existing engines without significantly increasing the size of the engine. Mounting flange portion 46 is approximately only 3 millimeters in thickness and therefore only slightly affects the size of the engine. Also, flange 46 can be easily formed with a specific number and pattern of mounting apertures so as to correspond to the mounting apertures on the cylinder head and delivery conduit of an existing engine. In many conventional engines, the air delivery conduit 18 functions as an aftercooler with heat exchanger tubes or panels carrying engine coolant positioned throughout the conduit. Many of these engines also include intake manifolds formed by separate conduits mounted on the cylinder head of the engine. The present invention avoids the need for yet another separate, large housing mounted along the air intake conduit by integrating both the intake air heater and the intake air manifold into the cylinder head. Thus, the present invention provides a simple, inexpensive intake air heater which can be easily retrofitted on an existing engine. In addition, the present invention provides a compact, more aesthetically

pleasing air delivery assembly which advantageously minimizes the size of the engine.

Industrial Applicability

5 The integrated air delivery assembly and intake air heater of the present invention can be used on virtually any internal combustion engine requiring the delivery of intake air, including in-line and V-type engines. The intake air heater of the present invention is particularly advantageous as an after-market product for retrofitting on existing engines.